Facts, Findings and Recommendations - Part 2
Oklahoma Outbreak

Local Office Warning and Forecast Service

FACT: At 12:30 p.m., May 3, a Thunderstorm Outlook was issued by NWSFO Norman upgrading the western half of Oklahoma to a moderate risk of severe thunderstorms. It noted the likelihood for some supercell thunderstorms and isolated tornadoes. Emergency managers and spotter groups were encouraged to be ready for possible activation later that afternoon.

FACT: During the main part of this severe weather episode (4 p.m., May 3, until 2 a.m., May 4), NWSFO Norman issued 116 warnings (70 tornado warnings; 46 severe thunderstorm warnings). In the Oklahoma City metropolitan area, the average lead time for the *first* tornado, in each county warned, was 32 minutes. NWSFO Norman's average lead time for *all* tornado warnings issued during this event was 18 minutes.

FACT: At 6:57 p.m., NWSFO Norman issued a uniquely worded SVS (headlined **"TORNADO EMERGENCY IN SOUTH OKLAHOMA CITY METRO AREA"**) which heightened awareness of this serious situation. It urged people in Moore and south Oklahoma City to take immediate tornado precautions (25 minutes before the tornado entered those areas). This SVS was formatted with the Specific Area Message Encoder (SAME) information and was tone-alerted on NWR. The phrase was picked up by media outlets and credited with adding the emphasis that prompted numerous residents to action.

FACT: Two members of the OSF assisted with the operations of the Norman NWSFO Principal User Processor (PUP) during the event and provided helpful feedback/analysis to the operational forecasters.

Systems

Weather Surveillance Radar-1988 Doppler (WSR-88D)

FACT: Most radar-based tornado warning decisions at NWSFO Norman were made using the base reflectivity, storm relative velocity and Vertically Integrated Liquid products from the WSR-88D.

FACT: One communications equipment malfunction (resulting in the loss of one volume scan) occurred with the Twin Lakes WSR-88D (KTLX) radar during the tornado event. The OSF Hotline staff (in the same building) came to the NWSFO to reset the WSR-88D. The forecast office staff did not have to become involved in problem resolution. That level of service is not available at other NWS field offices.

FACT: This Service Assessment focuses on the Oklahoma City and Wichita area tornadoes. However, it is noteworthy that, within this severe thunderstorm and tornado outbreak area on May 3, NWSO Wichita and NWSFO Tulsa were able to provide effective warning services during this event through the use of nearby WSR-88Ds. This is a testimony to the effectiveness of the redundant WSR-88D coverage (mainly east of the Rockies) and the back-up procedures employed by these two offices.

Finding 2: The NWSFO Tulsa WSR-88D gearbox malfunctioned and dropped into the azimuth electrical harness on May 2 at 10 a.m. Depot maintenance was dispatched from OSF within 4 hours and brought the system up 24 hours later.

Recommendation 2: Once the gearbox problem is determined, the OSF should implement appropriate maintenance procedures and/or fixes at all WSR-88D sites.

Warning Decision Support System (WDSS)

FACT: The NSSL-developed WDSS provided useful information to the warning staff at NWSFO Norman during the outbreak. WDSS offers access to the full wide-band suite of reflectivity and velocity data, improved algorithm guidance, and dynamic tables which rank storms according to algorithm-derived severe weather threats.

Finding 3: WDSS severe storm cell tables and trend displays focused the forecasters' attention on those storms that could require warning. WDSS displays of full resolution velocity products were confidence builders for tornado warning decisions. WDSS also incorporates advanced versions of the NSSL mesocyclone detection and tornado detection algorithms. The NEXRAD Open systems Radar Product Generator (ORPG) is required to implement advanced algorithms and to provide high resolution products to AWIPS for these WDSS capabilities. The NEXRAD Open systems Radar Data Acquisition (ORDA) will provide improved base data (e.g., high resolution reflectivity, better anomalous propagation suppression).

Recommendation 3: The National Weather Service should give high priority to the ORPG and ORDA projects and to the incorporation of high resolution WSR-88D data in the AWIPS Build 5.X series.

NOAA Weather Radio (NWR) / Console Replacement System (CRS) Performance

FACT: The CRS automated voice was used by NWSFO Norman during the event. CRS proved to be beneficial overall, as many statements and warnings reached the public faster than would have been possible via manual recordings.

FACT: Despite the speed advantage provided by CRS, there were some adverse occurrences. In NWSFO Norman's NWR coverage areas, 14 warnings (19 percent of the warnings broadcast) required manual transmission through the CRS Emergency Override. Quick action by the NWS enabled these warnings to be broadcast with delays of less than 60 seconds.

FACT: Fourteen warnings were not automatically broadcast due to software problems. CRS's Airwave formatter did not accept warnings with three bullets of information (compared to the "typical" four-bullet format referenced in Operations Manual Letter 1-98). CRS did not accept warnings that contained the "&" symbol (signifying a severe weather report) if that symbol was positioned before the latitude/longitude coordinates in WarnGen-created warnings; this symbol caused Airwave to lock up. Two warnings were not automatically broadcast due to the "Active/Inactive" bug (products flagged as neither active nor inactive, thus are not broadcast). Also, a software problem occurred with Bubble's communication with CRS (the "escape-a" bug).

The first two problems listed above were fixed by field personnel within days of the outbreak. The third was fixed with a patch from CommPower (a work-a-round was available on the NWS CRS Home Page 2 days after the outbreak). The fourth problem remains unsolved as of this writing.

FACT: To heighten awareness, 24 of the 48 SVS products issued during this event were broadcast using the warning alert tone. Because most SVS products are not tone-alerted, these urgent SVSs required manual intervention. CRS's Airwave formatter, along with AWIPS's WarnGen software, do not have the capability to produce both non-tone-alerted and tone-alerted SVS products.

Finding 4: Various CRS formatters in field offices provide a useful service but do not satisfy the needs of all offices. In addition, there are operational problems associated with most of these formatters. There is a need for standardized CRS formatter software to provide an efficient, reliable interface between AWIPS and CRS. Earlier this year, NWS regional representatives provided OSO a set of field requirements for a universal CRS formatter.

Recommendation 4a: OSO should establish a schedule for the development and implementation of universal, AWIPS-based, and nationally supported formatters for CRS.

Recommendation 4b: In the interim, OSO should establish a national forum to collect and publicize improvements and fixes that have been made to the CRS formatters currently in use.

AWIPS Performance

FACT: AWIPS was critical to the success of this event. It would have been impossible to duplicate the number of successful warnings and lead times and to keep track of the large number of severe storms with a mixture of PUPs, PCs and Automation of Field Operations and Services (AFOS) systems.

Finding 5: All warnings at NWSFO Norman were generated with WarnGen (AWIPS Build 4.1.1); the staff invested substantial effort during the months prior to the event, customizing preformats for warnings and SVSs, which included the generation of detailed city boundary backgrounds.

Recommendation 5: NWS regions should ensure that all forecast offices customize warning preformats and generate city boundary backgrounds for their CWAs.

Finding 6: AWIPS pixel replication zoom distortion led forecasters to supplement WSR-88D velocity data with alternate display systems (e.g., WDSS). AWIPS Build 4.2 provides non-distorted magnification but requires more time to display the product. Substantial improvement in performance will not be possible with the existing AWIPS hardware.

Recommendation 6a: For the near term Build 5 time frame, the AWIPS Program Office (APO) should make modifications that result in more rapid display of non-distorted magnified products within the existing AWIPS framework.

Recommendation 6b: For the long term, the APO should evaluate what improvements in display time could be achieved for non-distorted magnification of WSR-88D products as AWIPS hardware and software evolve.

Finding 7: The Norman NWSFO accessed, via the Internet, data sets not available through AWIPS and helped forecasters focus on the convective initiation over southwest Oklahoma. These included:

- Advanced Regional Prediction System model output from the Center for the Analysis and Prediction of Storms at the University of Oklahoma,
- RUC II model output, and
- the Oklahoma mesoscale network.

Methods for ingesting data sets into AWIPS, via Local Data Acquisition and Dissemination (LDAD), have been implemented at a few forecast offices but are not widely known or documented.

Recommendation 7: The APO should provide to the Regions for distribution to field offices documentation and procedures for using LDAD to ingest data sets not available through AWIPS.

FACT: The Norman NWSFO SOO alerted the Network Control Facility (NCF) at 5 p.m. and requested enhanced monitoring. The NCF opened a remote terminal session into Norman and was ready for problem resolution. When one of the radar data streams stopped coming into the AWIPS, the SOO notified NCF personnel who promptly performed a modem reset. This was the only modem reset required during this event.

FACT: The AWIPS program that sends data to AFOS failed once and delayed one warning by 30 seconds. Because this process fails often at NWSFO

Norman, the SOO anticipated this and had a remote terminal window open and ready to run "startAFOS."

Finding 8: AWIPS performed very well during this event. However, two interruptions of AWIPS processes (e.g., AWIPS to AFOS communication and WSR-88D to AWIPS communication) led to delays in product receipt and transmission. An additional delay was caused by having to contact the NCF. Also, a potential AWIPS point of failure, with respect to contacting the NCF, is possible when phone lines are unavailable, as was often the case at NWSFO Norman during this event.

Recommendation 8: The APO should develop a method to allow local restart of basic AWIPS processes, saving valuable time during severe weather events.

Internal and External Coordination

FACT: The Norman NWSFO's strong partnership with the amateur radio community in central and western Oklahoma proved very valuable on May 3. Amateur radio information played a crucial role in the warning process and in subsequent follow-up information (SVSs and LSRs). Seventy-five severe event reports were received via the amateur radio network. The office's amateur radios were of even greater importance that night since its phone service was often interrupted for several hours (6:30 p.m. until at least midnight).

FACT: Amateur radio repeaters helped keep the Norman NWSFO in contact with spotters and Emergency Operations Centers (EOCs) throughout the far reaching counties in its CWA. This was critical for these outlying communities because local TV coverage was focused on the Oklahoma City metropolitan area F5 tornado.

FACT: Post-storm visibility with the media was very positive. Local and national news coverage focused on the advance warning provided by the National Weather Service and the extensive live video coverage by the Oklahoma City TV stations. NWS Headquarters, SRH, NWSFO Norman, SPC, OSF and NSSL all participated in interviews following the event. There were over 200 media contacts following this event. Pro-active efforts by NOAA Public Affairs included:

- Press conference by NWSFO Norman, the SPC, OSF and NSSL on May 4, 1999.
- Press conference in Washington, DC, by NOAA Administrator D. James Baker and NWS Deputy Director John Jones.

- Several press releases and media advisories.
- A multitude of pro-active interviews with local reporters. Coverage included stories in several major newspapers and news magazines plus interviews and related coverage by the major television networks.

FACT: Soon after the live broadcast of the Presidential visit to the city on May 8, 1999, a TV newscaster from the Oklahoma City NBC affiliate, KFOR, thanked the National Weather Service for the advance warning.

FACT: The Moore Emergency Manager included a severe weather awareness insert in the city's water bills to residents during severe weather awareness week (held 2 months prior to the tornado). The insert gave specific instructions on what the residents should do in the event of a tornado. The Norman NWSFO gave technical assistance to the emergency manager on this project.

FACT: A large Oklahoma City area telecommunications company called NWSFO Norman after the tornado to express thanks for their assistance in updating the company's severe weather safety plan, completed prior to the tornado. The new plan instructed employees not to travel home during a tornado for safety reasons. This was a significant change from the previous plan, which allowed employees to go home. The new plan may have saved lives since the F5 tornado passed within 1 mile of the company.

Dissemination

FACT: Interviews with several Oklahoma City radio stations (KNOR, KOMA, KQCV, KTOK, KATT, KYIS, KCYI, KNTL and WWLS) indicated that NWR information was used often in their operations during the outbreak. One general manager said that he was "grateful" for the NWR service, while another station's official said that his station "lives and dies by" NWR.

FACT: CRS voice quality was not a major issue in this event, at least with the limited number of customers interviewed. During the event, some stations played the actual NWR automated voice on the air, although one radio station's general manager acknowledged that they did not air the actual broadcast due to CRS's "poor voice quality." In the weeks following the event, NWSFO Norman received some voice quality complaints from the public.

FACT: The Deputy Director of the Oklahoma Civil Emergency Management agency stated EMWIN provided prompt information to the emergency managers during this event. He further stated EMWIN is one of the most valuable emergency management tools to come along in many years.

FACT: Local emergency management officials cited the OK-FIRST system as a very helpful weather information tool. The OK-FIRST system includes Internet access to real-time WSR-88D radar data plus all NWS text products. This system was developed by the Oklahoma Climatological Survey. The Norman NWSFO staff and OSF Training Branch assisted the OCS in its extensive training of OK-FIRST users.

Finding 9: In addition to the NWS text products, such as warnings and follow-up statements, real-time radar data was available to some emergency managers via OK-FIRST. These radar data provided valuable information on storm structure, location and track of the storms. A basic set of WSR-88D products will soon be available (in Build 4.3) on the AWIPS Satellite Broadcast Network. However, these products cannot be made available outside the NWS until the NEXRAD Information Dissemination Service (NIDS) contract expires.

Recommendation 9: The APO should devise a method that can be implemented, once the NIDS vendor contract expires, whereby partners and customers can access a basic set of radar products in real-time.

Response

FACT: The ample National Weather Service warning lead times and live local TV coverage allowed many individuals to escape the path of this tornado (from their homes) via automobile.

FACT: A Grady County resident living in an area with primarily mobile homes credited advance National Weather Service warnings with saving many lives in his neighborhood. The early warning gave his family time to gather neighbors into his storm cellar. Thirty-five people crammed into the cellar. The winds from the F5 tornado pulled the cellar door open, but all survived. Their mobile homes were destroyed.

FACT: Citing advance National Weather Service warnings, a Grady County Deputy Sheriff was able to pre-position himself close to the projected path of the tornado to immediately deploy into the stricken area after it passed. As a result, he was on the scene of some of the worst destruction in his county and delivered emergency care to casualties.

FACT: An award ceremony at West Moore High School could have ended in disaster without the quick thinking of the school's assistant principal. The assistant school principal ushered the participants and guests into the interior hallways and bathrooms. The roof of the gym was ripped off by the tornado. There were no fatalities at the school.

FACT: Using National Weather Service warnings and radar information, as well as their own radars, TV stations in Oklahoma City are credited with helping save many lives. TV coverage of the Oklahoma City metro area F5 tornado is regarded as an extraordinary event. Two news helicopters flew adjacent to the tornado reporting the location and path to the public. One station simultaneously showed a text box on the screen with projected street names the tornado would hit and approximate time the tornado would reach a particular site.

Finding 10: Two deaths were attributed to individuals seeking shelter under highway overpasses during this event. There were also reports of people who were severely injured after seeking shelter under overpasses.

Recommendation 10: NOAA Public Affairs, with assistance from the Office of Meteorology, should update tornado safety brochures with statements which warn against seeking shelter under overpasses during a tornadic event.

Training

FACT: The Norman NWSFO staff completed a severe weather drill just prior to the May 3, 1999, outbreak. One part of the drill was a scenario which simulated a violent tornado approaching Oklahoma City. Each forecaster was required to write appropriate warnings and NOWs for such an event.

Management Procedures

FACT: The Norman NWSFO has encouraged and nurtured a productive partnership with the local agencies, the University of Oklahoma and the public to assist in weather-related scenarios. Early in the morning on May 4 following the tornado outbreak, there were enough qualified volunteers (including volunteers from all local NOAA components) to assemble nine storm survey teams. These quality surveys were posted on the NWSFO Norman Home Page soon after the event. This was very helpful to the Service Assessment Team. Although such a rapid and thorough survey cannot be expected at other offices in the country, it does point to the importance of being prepared for a quick response.

Devastating tornado damage in the small community of Haysville, south of Wichita, Kansas. (Photograph courtesy of John Ogren, NWSO Wichita, Kansas)